radiotherapy (IGRT), has highlighted deficiencies in target delineations based on CT. Several studies have shown large variability in target definitions based on CT, for multiple treatment sites. To address this issue, magnetic resonance imaging (MRI) has made its way into the clinical routine at modern radiotherapy departments over the last years. This, however, has presented several new problems that need to be solved.
The traditional method of including MR information in the radiotherapy process is as a complement to the CT. To accomplish this in an integrated and accurate fashion, the images must be placed in a common coordinate system through image registration. This process in itself introduces new uncertainties into the treatment chain, which must be quantified and minimized. Another method of using MR information is to base the entire treatment on MR and exclude the CT altogether. This alleviates uncertainties that stem from the image registration process, but introduces another set of problems. To perform accurate dose calculations, heterogeneity corrections based on CT data have been the clinical standard for many years. MR data does not provide information that can be used for such corrections; however, much research effort has been invested in creating valid photon attenuation maps from MR data over the last years.
Whatever method employed, MR for radiotherapy purposes also imposes practical issues that need to be addressed. The patient needs to be positioned in the same way that will be employed during the radiotherapy itself. This includes a flat table top and immobilization devices such as cast masks and tilted boards, which may not be MR compatible. For example, many radiotherapy fixation devices can contain metal parts such as nuts and bolts, which cannot be used in the MR. Plastic replacements must be used instead. Also, the standard MR coils will often not accommodate the immobilized patient, which forces MR adopters to acquire special coils or coil holders for flexible coils to be able to scan the patient in the radiotherapy treatment position.
MR images do not have the same geometric integrity as CT, which is an issue in the radiotherapy setting. The image distortions can come from the machine itself or from the patient that is in the machine. Machine specific distortions are caused by inhomogeneity in the main magnetic field or gradient non-linearity. Patient specific distortions are mostly caused by susceptibility effects. The machine specific distortions can be measured, modelled and corrected for to a certain extent, while patient specific distortions often needs to be handled by choosing imaging parameters wisely.
In the end, the images acquired from the MR scanner must be of sufficient quality to allow physicians to base the radiotherapy treatment on them. MR for radiotherapy has a different set of demands on the images than their diagnostic counterparts, for example slice thickness and gap, as well as other parameters. Also, the vast variety of MR contrasts may be an initial obstacle for radiotherapy oncologists. Many studies have shown differences in target definitions based on CT and MR images, and the effects of these changes in target volumes have not yet been studied in clinical trials.

Teaching Lecture: Patient specific quality assurance in proton therapy

SP-0007
Patient specific quality assurance in proton therapy

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Interest in proton therapy continues to grow worldwide, yet access to proton therapy facilities remains relatively low compared to those offering conventional radiotherapy. As a consequence, pressure exists to maximize patient throughput in each facility. Most facilities operate 24 hours per day, 7 days per week to meet the demands of the clinical load and to complete machine maintenance, routine quality assurance, and patient specific quality assurance. With the advent of advanced delivery techniques such as pencil beam scanning, the complexity of patient specific quality assurance is increasing. However, there is a need to improve efficiency of these tests whilst maintaining accuracy.
This presentation will summarize contemporary patient specific quality assurance practice for both passive scattering and pencil beam scanning proton therapy, and describe off-line tests that potentially enable improved efficiency.

Teaching Lecture: Balancing toxicity and disease control in the evolution of radiotherapy technology

SP-0008
Balancing toxicity and disease control in the evolution of radiotherapy technology

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Radiotherapy (RT) is an effective option for treatment of many cancers. It offers organ and functional preservation and enhances surgical outcomes when administered pre-operatively or post-operatively, and for some diseases, such as nasopharyngeal cancer, it is often the only curative option. Disease control is generally of paramount importance to most patients during the urgent point of decision-making following diagnosis. However toxicity will almost certainly emerge as being just as relevant in the aftermath of treatment and in the subsequent follow-up period. In essence, when a patient dies of toxicity or treatment-related complications, it is just as tragic as dying of disease. The long-term result of RTOG 9111 and 9501 suggest that treatment -related deaths are blunting originally observed difference in cancer-related outcome. The recent RTOG 0617 trial was designed to test whether a higher RT dose (74 Gy vs 60 Gy) +/- cetuximab could confer a survival benefit but showed an unexpected therapeutic “disadvantage” with higher RT dose attributable to significant acute and late toxicities. These findings highlight the importance of balancing toxicity and disease control to optimize therapeutic gain. Several strategies have been employed to mitigate toxicities, such as respecting the biology of radiation injury by altered dose fractionation (typically using smaller than conventional fractions), or optimising radiotherapy technical delivery to reduce dose to vulnerable anatomy. Implementing novel RT technologies need to be closely monitored to prove clinical benefit. Historical lessons have shown that putative benefits may not always transfer to real clinical advantages since many unforeseen factors may modify potential anticipated gains. While modern RT technologies, such as IMRT-IGRT, adaptive, and IMPT provide opportunities to reduce RT late toxicity by providing more conformal dose distribution to spatially avoid normal tissue, the steps to achieve this are complex. One needs to appreciate many diverse factors. These include radiobiology of normal tissue (dose/constraints), optimal imaging quality and registration, systematic quality control involving “target” delineation to delivery, and knowledge of a variety of inherent pitfalls in the process(e.g. poor delineation, dose dumping, erratic planning, tumor or normal tissue deformation, and set up uncertainties that may emerge throughout the treatment course). For example, beam path toxicities have been reported due to “dose dumping” from parotid-sparing IMRT in head and neck cancer. Increased local failure has been observed when delivering tight margin carotid-sparing partial organ irradiation for T2 glottic cancer using vertebrae rather than laryngeal soft tissue as the image guidance surrogate. Adaptive radiotherapy appears to be feasible in some situations but the therapeutic advantages are yet to be proven and may be tedious and inefficient under the current technical configurations of many departments. Also, while intensity-modulated proton therapy (IMPT) is an attractive emerging approach that is probably able to spare normal tissue, indications and clinical benefit are also largely unproven at this time. The path to implementing these approaches will require rigorous